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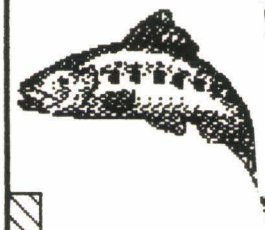

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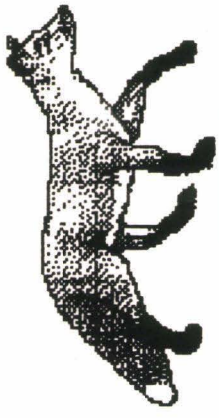
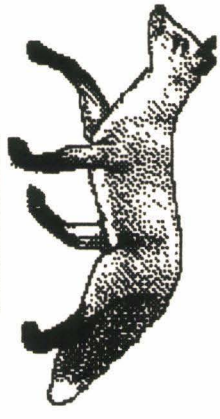
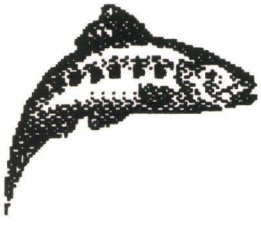
April 1993

INTEGRATING THE SELECTION OF CONSTRUCTION MATERIALS FOR BOARDWALKS WITH THE NEEDS OF SENSITIVE HABITATS AND KEY SPECIES ON THE MT. HOOD NATIONAL FOREST







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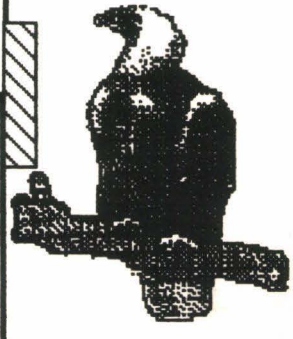

"Poison is in everything and no thing is without poison. Only the dosage makes it either a poison or a remedy."

Paracelsus
Swiss Physician and Alchemist
1493-1541

ABSTRACT

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TITLE: Integrating the Selection of Construction Materials for Boardwalks with the Needs of Sensitive Habitats and Key Species on the Mt. Hood National Forest.

ABSTRACT: The Mt. Hood National Forest has an extensive trail system providing our customers with a variety of trail opportunities from hiker-only wilderness trails to barrier-free boardwalks. These trails require a wide spectrum of construction materials. An increased awareness for sensitive habitats and key species by ecosystem specialists has created various conflicts with trail planners and designers regarding the use of some of these construction materials. Especially in the use of boardwalk materials. One of the challenges facing trail managers on the Mt. Hood National Forest is integrating the use of construction materials for boardwalks with the needs of sensitive habitats and key species, and still provide economical and durable trail facilities that meet our customers' needs.

These challenges can be resolved through the following four step approach:

1. Identify the types of materials used in the construction of boardwalks.
2. Identify key species and sensitive habitats on the Mt. Hood National Forest that could be affected by the materials used in boardwalk construction.
3. Develop guidelines that address the types of boardwalk materials that are acceptable for use in a given habitat.
4. Identify monitoring procedures to test the effectiveness of the guidelines and validate any assumptions that were made.

With the decline in our natural resources, such as wood, and increasing costs for construction materials it is important that we utilize the most durable, cost effective materials possible. At the same time we must protect key species and sensitive habitats. The goal of this project is to integrate these two needs.

Keywords: Key Species, Sensitive Habitats, Boardwalk, Trail

TABLE OF CONTENTS

EXECUTIVE SUMMARY 3

I. INTRODUCTION 6
- Project Goal 6
- Project Objectives 7
- Project Scope 7
- Project Background 8

II. LITERATURE REVIEW 9

III. BACKGROUND 12
- Key Species 12
- Plants 16
- Sensitive Habitats 17
- Boardwalk Materials 22
- Boardwalk Material Guidelines 36

IV. RECOMMENDATIONS 40

V. MONITORING 43

VI. FUTURE RESEARCH NEEDS 49

VII. SUMMARY 50

VIII. LITERATURE CITED 51

EXECUTIVE SUMMARY

TITLE: Integrating the Selection of Construction Materials for Boardwalks with the Needs of Sensitive Habitats and Key Species on the Mt. Hood National Forest.

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SUMMARY: This report identifies guidelines for selecting the type of boardwalk materials to be used in sensitive habitats that contain key species. There are six main sections in this report including an introduction; a literature review; background, consisting of the identification of key species, sensitive habitats, boardwalk materials and guidelines for the selection of boardwalk materials; monitoring procedures; future research needs; and a summary. The following is a synopsis of these sections.

Introduction:

The Mt. Hood National Forest has an extensive trail system utilizing a broad array of construction materials. An increased awareness for sensitive habitats and key species has caused some conflicts relating to the use of some of these materials. Particularly those used in the construction of boardwalks.

The goal of this project is to integrate the selection of construction materials for boardwalks with the needs of sensitive habitats and key species.

The objectives developed to achieve this goal are :

1. Identify the types of materials used in the construction of boardwalks.
2. Identify key species and sensitive habitats on the Mt. Hood National Forest that could be affected by the materials used in boardwalk construction.
3. Develop guidelines that address the types of boardwalk materials that are acceptable for use in a given habitat.
4. Identify monitoring procedures to test the effectiveness of the guidelines and validate any assumptions that were made.

The scope of this project focuses on the in-service losses of components from boardwalk materials and their affect on key species and sensitive habitats.

Literature Review:

Literature was reviewed to document the type and amount of components that leach from commonly used boardwalk materials, and how they affect the environment. The literature was lacking in studies relating to actual field tests of the environmental effects of boardwalk materials.

Background:

This project identified key species, sensitive habitats and boardwalk materials. Guidelines were then developed that integrated these three.

The key species were grouped into five categories consisting of avian, amphibian, aquatic reptiles, salmonid fish and aquatic invertebrates. These groups represent species that are potentially sensitive to the type of materials used in boardwalk construction and at least one of the following: (1) the species represents significant ecological or economic importance; (2) the species represents a unique, limited or sensitive habitat. The discussion of each group was organized into 2 parts: (1) the species' life requisites and habitat needs are briefly explained and (2) potential impacts caused by the type of materials used in boardwalk construction are identified.

The sensitive habitats identified as being potentially sensitive to the effects of in-service losses of components from boardwalk materials were riparian, wetlands, meadows, and salmonid fish spawning and rearing habitats. These habitats are also either ecologically unique or they provide essential habitat for a key species during a critical period of the species' life history. Potential impacts to these habitats are briefly described.

Boardwalk materials were grouped into 3 broad types including untreated wood, preservative treated wood and plastic lumber. The discussion of each material type was organized into 4 parts: (1) a description of the material; (2) the average life of the material is identified (based on outdoor, ground contact use); (3) the average cost for the material, as it is used in boardwalk construction, is identified; (4) potential effects on the environment are described. Very little literature existed on untreated wood and plastic lumber relating to their affects on the environment. Preservative treated wood has been studied extensively with respect to leaching, but the studies stopped short of determining what effect this leaching had on the environment.

Subjective guidelines were developed for the use of boardwalk materials in sensitive habitats based on the literature reviewed, assumptions made and the biological evaluation process. The guidelines focused on the short term with

mitigation measures identified and recommendations made. Cost and durability were also factored into the equation. Preservative treated wood was recommended for most applications of boardwalk construction.

Monitoring:

The monitoring plan is the tool used to validate the assumptions made in the guidelines. The monitoring plan was split into two parts. The first part is a species and habitat matrix which outlines the monitoring method, unit of measure, monitoring frequency, and threshold of variability for each key species and sensitive habitat. The second part addresses the need to monitor the in-service losses of chemical components from the boardwalk materials and how they affect key species.

Future Research Needs:

Future research is needed to move from a short term approach to a more definitive solution regarding the acceptability of boardwalk materials. Studies need to be conducted involving in-field use of the boardwalk materials. These needs include leaching studies with respect to the effects on key species and sensitive habitats.

Summary:

This project made it clear that the selection of boardwalk material is very subjective with respect to it's effects on key species and sensitive habitats, and the risks need to be weighed against the benefits.

With the decline in our natural resources, such as wood, and increasing costs for construction materials it is important that we utilize the most durable cost effective materials possible. At the same time we must protect key species and sensitive habitats. This project is the first step in integrating the needs of sensitive habitats and key species with the selection of boardwalk materials.

I. INTRODUCTION

The Mt. Hood National Forest has an extensive trail system providing our customers with a variety of trail opportunities ranging from hiker-only wilderness trails to barrier-free boardwalks. The construction of new trails, as well as the maintenance and reconstruction of existing trails, requires a wide spectrum of construction materials. An increased awareness for sensitive habitats and key species by ecosystem specialists has created various conflicts with trail planners and designers regarding the use of some of these construction materials. Especially in the use of boardwalk materials.

One of the challenges facing trail managers on the Mt. Hood National Forest is to integrate the use of construction materials for boardwalks with the needs of sensitive habitats and key species, and still provide economical and durable trail facilities that meet our customers' needs. The lack of established standards or guidelines for the acceptable use of these construction materials in sensitive habitats makes this difficult. Currently, the acceptability varies depending on which District the project is on and which specialist you are working with. This has caused project delays, shortened life spans for structures, unacceptable use of some types of materials in sensitive habitats, and difficulties for the Line Officer in making decisions regarding the acceptability of projects.

The solution is to examine sensitive habitat needs, our customers' needs, and the need to provide the most durable and economical trail facilities possible. Then make informed management decisions recognizing the consequences of our choices. This can be enhanced with a better understanding of the different types of materials and their acceptability for use in a particular habitat.

A. Project Goal

The goal of this project is to integrate the selection of construction materials for boardwalks with the needs of sensitive habitats and key species.

B. Project Objectives

The objectives of this project are:

1. Identify the types of materials used in the construction of boardwalks.
2. Identify key species and sensitive habitats on the Mt. Hood National Forest that could be affected by the materials used in boardwalk construction.
3. Develop guidelines that address the types of boardwalk materials that are acceptable for use in a given habitat.
4. Identify monitoring procedures to test the effectiveness of the guidelines and validate any assumptions that were made.

C. Project Scope

The Mt. Hood National Forest is an Urban Forest with over 1200 miles of trails traversing a variety of habitats and utilizing a broad array of construction materials. There are increasing conflicts involving the use of some of these materials brought about by a heightened awareness for sensitive habitats and species. The majority of these conflicts are in wet areas, around lakes and waterways, and through meadows where trails require a hardened surface. This is compounded because as an Urban Forest there is an increasing need for more barrier-free trails requiring a surface that can accommodate all uses including wheelchairs. This surface is typically a boardwalk.

This report focuses on the materials commonly used in boardwalk construction, and on habitats and key species that could be affected by the type of materials used. This report also develops guidelines for the selection of materials that are sensitive to the needs of affected habitats and key species; while also factoring in the customers' needs and economics. It was recognized that the information relating to the effects of preservative treated material on habitats and key species is limited and additional research is needed.

D. Project Background

Until recently, trails have to a large part been ignored with respect to their affect on the environment. In the past few years fish and wildlife specialists on the Mt. Hood National Forest have been increasingly focused on the potential impacts trails could have on sensitive habitats and key species, particularly with respect to the types of materials used in boardwalks. This has been compounded by the increase in the number of trails being constructed in sensitive habitats that require the use of boardwalk materials. These facts combined with several recent articles (ie. Arsenic and Old Lakes, J. Sanders, 1991) that were critical of the wood preservative treatments commonly used in boardwalks prompted ZigZag District biologists to perform a literature search on these treatments before making any recommendations in future project biological evaluations. This project builds on the information researched and sets the stage for the development of Forest-wide guidelines.

II. LITERATURE REVIEW

This literature review utilized two detailed literature searches and reviews as the cornerstone for the information used in this report. The literature search conducted by the Zigzag District biologists focused on the wood preservative treatments commonly being used on the Forest, chromated copper arsenate (CCA) and copper naphthenate. This search was used in the Hughes (1992) biological evaluation of the Summit Trail project. FS/INFO NW Services supplemented with additional articles and phone contacts were utilized in this literature search. The Doyle et al. (1992) review collected and summarized the available literature relating to health, safety and the environment with respect to the use of heavy duty wood preservatives.

As a part of the Doyle et al. (1992) review a working group was formed to review the environmental impacts of wood preservatives. This group focused on the leaching losses of treated wood, comparing concentrations in environmental matrices with existing guidelines, and assessing whether the expected levels of contamination could result in significant impacts to the biota. The primary conclusions were that fixation of the chemicals in the wood is important and that aquatic systems were the most sensitive to the chemicals that leach out, with copper causing the most concern.

In the Hughes (1992) review it was determined that while there is no conclusive evidence that CCA or copper naphthenate treated wood should not be used, it has been determined that there are toxic effects to plants and animals from both treatments, and more research needs to be done.

Additional literature was researched and personal contacts made to supplement these two reviews. Particularly with respect to information on new products, and new studies that either supported or refuted studies in the Hughes (1992) and Doyle et al. (1992) reviews.

The majority of the literature searched focused on studies of three of the six types

of boardwalk materials included in this report; CCA, copper naphthenate, and ammoniacal copper zinc arsenate(ACZA). Of the remaining three, ammoniacal copper quat (ACQ) and plastic lumber have not been around long enough to have accumulated much test data, and cedar is a naturally occurring material whose use has not warranted study. Also, the focus of the studies that were conducted was on the leaching of chemicals from preservative treated wood, and the assumed effect this would have on it's life and the environment.

In Webb et al. (1988) it was concluded that preservatives do not move and migrate from the treated wood causing a significant environmental hazard, and they are not a potential risk through bio-accumulation. The Arsenault (1975) study concluded that CCA treated wood does not leach a significant amount of preservative components and there is no environmental hazard to ground water, soils, plants, or animals. Similarly, DeGroot et al. (1979) summized that wood preservatives are strongly fixed within the wood. In contrast, Weis et al. (1988) concluded that metals do leach out from CCA-treated wood and they can be toxic to some estuarine species. Also, Doyle et al. (1992) determined that copper naphthenate and CCA treated wood do leach their respective chemical components and the losses could result in environmental contamination due to the copper if used in water or where run-off enters directly into water.

These studies differ in their assumptions regarding the amount of material leached from treated wood and its' subsequent effect on the environment but, they all allude to the importance of the fixation of the preservative in the wood.

Other studies conducted include the toxic effects of copper naphthenate on mammalian, avian, and aquatic test systems (USAEHA, 1988); the effects of CCA treated wood wood on selected estuarine organisms (Weis, 1988); and the effect of CCA and copper naphthenate wood preservative treatment of beehives on honey bees and hive products (Kalnins et al., 1986).

Even though there has been a wide variety of studies conducted on preservative treated wood, there is a lack of quantitative documentation, based on actual field studies, on the effects the use of preservative treated wood, plastic lumber, and

cedar have on the environment. Until these field studies are conducted the decisions on the type of boardwalk materials to use will be restricted to individual judgment, which could have negative consequences relative to cost, the environment, and the customer.

III. BACKGROUND

Key Species

The type of materials used in the construction of boardwalks is a concern to the following key species because the species is potentially sensitive to the effects of these materials and at least one of the following: (1) the species represents significant ecological or economic importance; (2) the species represents a unique, limited or sensitive habitat. Based on the literature researched and personal communication with Forest biologists the key species can be grouped into five broad categories with respect to the potential impacts caused by boardwalk materials. These five categories are avian, amphibian, aquatic reptiles, salmonid fish, and aquatic invertebrate.

The following discussion of each key species group is organized into 2 parts: (1) the species' life requisites and habitat needs are briefly explained; (2) potential impacts caused by the type of materials used in boardwalk construction are identified. A large part of the following information on the species life requisites was obtained directly from the Sachet (1990) report and a report developed by specialists on the Mt. Hood NF describing threatened, endangered, candidate and sensitive species on the Forest. The remainder was obtained from other literature and personal communications with specialists.

Avian

The avian key species described in the Sachet (1990) report that live and/or feed in areas most likely to contain or require boardwalks are the peregrine falcon, bald eagle, spotted owl, and the greater sandhill crane. The American peregrine falcon generally prefers open country such as marshes, coastal and river shorelines, estuaries, and wide meadows, and have been known to nest on river banks. Bald eagles are usually within two miles and most often within 0.5 miles of a body of water and frequent the shorelines of rivers, coasts, and streams, or wherever there are concentrations of waterfowl or sizable fish runs. Sandhill cranes are omnivorous birds that feed on small reptiles, amphibians, rodents,

grains, roots, and insects found in wetlands, woodlands, sagebrush, and crop lands. Their key habitat for nesting includes undisturbed willow-lined stream courses, wetlands, beaver dams and hummocks surrounded by dense brush. (Sachet, 1990)

The only potential impacts that boardwalk materials could have on these species is from chemicals that may leach out, bio-accumulate through the food chain, and be ingested during feeding. Any impacts that might exist would be minimal. This is shown in the USAEHA (1988) study in which a dosage with copper naphthenate in two species of bird failed to produce significant observable toxic effects at high dietary concentrations indicating the compound would have little or no impact on wildfowl in the event of environmental contamination. The Doyle (1992) report indicated that the greatest concern to the environment from boardwalk materials is the leaching of copper, and copper toxicity is of little concern to mammals and birds.

Amphibian

The key species of amphibians are the red-legged frog and Cope's giant salamander, which are both classified as sensitive species. The red-legged frog is described as inhabiting ponds, marshes, rivers and streams in coniferous forests where vegetation at the water's edge, such as cattail, provides good cover. After heavy rains, they often disperse to damp woods and meadows away from permanent water sources. Requirements of breeding sites are that they have little or no flow, must last long enough for metamorphosis to occur, and have sturdy underwater stems of some sort for egg attachment. The Cope's giant salamander's habitat is streams and seepages in moist coniferous forests with water temperatures that range from 8-14 degrees Celsius, not exceeding 18 degrees Celsius. They are usually found under stones, slabs of bark, or other cover in streams. Stones, cutbanks, and logs provide habitat for nest chambers. (ZigZag)

In the literature searched there were no studies directly related to the effects of boardwalk materials on amphibians. Studies have shown that copper is lethal at

low doses to aquatic organisms, (Doyle, 1992) which means it may have similar effects to amphibians. Another concern with amphibians is that they are largely found under wood where moisture and cooler temperatures can be found, and by placing boardwalks in aquatic environments habitat is being created for them, (Hughes, 1992). There is a potential for this to be a toxic habitat depending on the type of boardwalk materials used.

Aquatic Reptiles

The key species of reptiles are the painted turtle and western pond turtle which are classified as sensitive and candidate species, respectively. The western pond turtle inhabits ponds, marshes and slow-moving portions of creeks and rivers which have rocky or muddy bottoms. The habitat for the painted turtle is ponds, marshes, small lakes, ditches and streams where the water is quiet or sluggish, the bottom is sandy or muddy, and there is considerable vegetation. Partially submerged logs, vegetation mats, mudbanks, rocks and tree branches provide areas for sunning for both species. (ZigZag)

In the literature searched there were no studies directly related to the effects of boardwalk materials on reptiles. This is similar to the amphibians, but unlike the amphibians these reptilian species are not usually found under wood and the placing of boardwalks in aquatic environments does not create habitat for them.

Salmonid Fish

Salmonid fish of the Mt. Hood National Forest utilize a wide variety of lakes and streams ranging in size from headwater tributaries to the mainstream Columbia River. The majority of spawning and rearing by salmon, steelhead, and trout in forested watersheds takes place in second, third, and fourth order streams. Additionally, the quality of the first order streams is vital to the quality of the salmonid habitat downstream. For optimum production, all salmonid species require cool, continuous flowing waters; free migration access to and from the sea (if anadromous); clean gravel substrate for reproduction; water of low-sediment content during the growing season (for sight feeding); high levels of dissolved oxygen content in streams, lakes and intragravel environment;

sufficient in stream cover; and invertebrate organisms for food. The habitats along the edges and side channels of streams are critical for summer rearing and overwintering of juvenile fish. This habitat provides cover and an aquatic insect food source. (Sachet, 1990)

Salmonid fish are the species that are most at risk from the type of materials used in boardwalk construction. Based on the studies researched, the boardwalk materials that pose the greatest potential risk to the aquatic environment are those that contain copper. Copper is lethal at low doses to aquatic organisms, and aquatic systems are considered to be very sensitive to copper, (Doyle, 1992). Wood treated with copper based preservatives could result in environmental contamination due to the copper, when used in water or where run-off enters directly into surface water, (Doyle, 1992). One study has shown that copper naphthenate is highly toxic to trout (USAEHA, 1988); and in the Weis *et al* (1988) study it was concluded that significant water contamination can occur in estuarine environments from the use of CCA treated wood, based on laboratory simulation.

Aquatic Invertebrates

The key species of aquatic invertebrates on the Mt. Hood NF are four species of the caddisfly. These are the Mt. Hood primitive brachycentrid, the Cascades apatanian, the Mt. Hood farulan, and the one-spot rhyacophilan (Wisseman, 1990), and they are all candidate species. The following key habitat characteristics are taken directly from the Wisseman (1990) review:

+ Cascades apatanian, Mt. Hood farulan, and one-spot rhyacophilan - Streams or springs having moderate to high gradients; dense coniferous canopy; stable, cobble, moss, and bole-wood substrates; cool year-round water temperatures; and no inputs of glacial meltwater and sediment.

+ Mt. Hood primitive brachycentrid - Small, cold, moderate to high gradient, perennial spring channels which are densely shaded by a coniferous overstory and a deciduous understory. Larvae appear to be restricted to

spring channels having a significant portion of their benthic substrates consisting of submerged moss and generally about 0.5 meters in width or less.

Since aquatic invertebrates are also aquatic organisms the risks as described in Salmonid fish above would generally apply to these species. Aquatic toxicity studies using copper naphthenate conducted on the micro-invertabrate Daphnia (water flea) showed abnormal effects of mortality, quiescence, surfacing and loss of equilibrium at concentrations above 1 mg/liter, (USAEHA, 1988).

Plants

The concerns expressed by Forest specialists, with respect to plants and the type of materials used in boardwalk construction, are with the use of preservative treated wood. This concern focuses on how the chemicals used in these preservatives might affect plants and how an organism that consumes these plants might be affected. (Personal communications with Forest specialists, 1993)

In a North Carolina State University study the affects of Chromated Copper Arsenate (CCA) treated stakes on grape plants showed no evidence of uptake and translocation of copper, chromium or arsenic from the soil to leaf, stem or fruit of the plants. This indicated no movement from the treated posts to the plants either from freshly treated (still wet) posts or seasoned posts. (Arsenault, 1975)

The Christensen, 1967 study on the effect of CCA treated plant boxes on the development of a variety of plants showed a slight effect on some root development with no effect on the roots of tomato plants. These effects were minimized if the boxes were washed after the treatment. In no case was there any evidence of effect on the plant to top development. (Arsenault, 1975)

In a study of copper toxicity from copper-treated burlap used to enclose the root balls of plants it was determined that copper naphthenate treated burlap was not toxic at any level studied and can be safely used up to four per cent copper. This is a level five times higher than necessary to protect burlap for six to nine

months. (Kuhns, 1976)

Independent research by Finch (a Bexar County, Texas Cooperative Extension agent) and Dr. Dainello (a Vegetable Specialist) concluded that CCA treated timbers are safe to use for raised-bed vegetable gardens. The research determined if treated landscape timbers, varying in usage from six months to nine years, were leaching any preservatives into the soil in raised garden beds. Samples were taken six inches deep, one inch and twelve inches from the treated timbers, in nine separate gardens of various ages. The samples were sent to two independent labs and the test results indicated that the levels of arsenic in the soil samples varied from 1.1 parts per million (ppm) to 14 ppm which is well within the normal range of 1 - 20 ppm for all soils. Since the levels of arsenic were nearly the same in soil samples 1 inch from the wood to 12 inches from the wood Finch and Dainello concluded that the arsenic detected came from the soil and not the treated timbers. (News, 1993)

Based on these studies it would appear that any detrimental effect on plants caused by wood treated with a preservative containing copper, chromium and/or arsenic would just as likely be caused by the wood crushing the plants as from the chemicals leaching from the treated wood. This would indicate that if the construction of a boardwalk using treated wood is a concern with respect to plants then the construction of a boardwalk itself should be a concern.

Sensitive Habitats

The types of materials used in the construction of boardwalks is a concern to the following habitats because the habitat is potentially sensitive to the effects of these materials and at least one of the following: (1) the habitats are ecologically unique; (2) they provide essential habitat for a key species during a critical period of the species' life history.

The following discussion of sensitive habitats covers three areas: (1) the physical attributes of each habitat is briefly explained; (2) the importance of the habitat to

wildlife, particularly key species is discussed; and (3) potential impacts caused by the type of materials used in boardwalk construction are identified.

The majority of the following information describing habitats was obtained directly from the Sachet (1990) report.

Riparian Zones

Riparian zones are among the most heavily used wildlife and people habitats occurring on the Mt. Hood National Forest. The riparian zone or habitat is the area that lies between the aquatic and terrestrial ecosystem. These zones can be identified by the presence of vegetation that requires free or unbound water, or conditions more moist than normal. Riparian zones occur along rivers, streams, intermittent drainages, ponds, lakes, reservoirs, springs, and wetlands. There is a great variability in both size and vegetative complexity of riparian zones because of the variety of combinations between the physical and biological characteristics. These characteristics include stream gradient, elevation, soil, aspect, topography, water quantity and quality, type of stream bottom, and plant community.

Wildlife use riparian areas disproportionately more than any other type of habitat and the critical importance of riparian zones is attributed to wildlife for a variety of reasons:

+ The presence of water increases the importance of the zone. Wildlife habitat is composed of cover, food, and water. These zones offer any one of these essential components, and often all three in close proximity.

+ The greater availability of water to plants, often in combination with deeper soils, increases plant biomass production. This leads to increased diversity of plant species and structural diversity in plant communities.

+ Structural diversity of the ecosystem is increased due to the contrast in plant communities between the riparian area and adjacent upland forest.

+ The linear shape of streams and associated riparian areas maximize the productive habitat edges.

+ Riparian zones in coniferous forests often produce a high edge-to-area ratio. The stairstep development of contrasting vegetation, i.e. deciduous versus coniferous, and shrubs versus trees, provides diverse nesting and feeding opportunities for wildlife.

+ Riparian areas along permanent and intermittent rivers and streams provide important migration, travel, and dispersal routes for wildlife, and vegetative connectors between forest habitats.

The habitat functions that attract wildlife to riparian areas are described as:

+ Forage and water: Riparian zones provide an abundance and variety of food for wildlife because of the diversity in vegetation. The free water that is commonly available is critically important to many species of wildlife. Riparian vegetation provides habitat for insects and a source of organic matter for aquatic insects which form the food supply of salmonid fishes.

+ Breeding and rearing: The diversity of a riparian area provides a wide variety of habitats where wildlife can breed and rear young. Riparian vegetation helps maintain quality fish spawning grounds by filtering sediments from surface runoff.

+ Hiding and Resting: The dense vegetation, complex landforms, and abundant water found in riparian zones provide an essential hiding, and resting element for many wildlife species. Riparian zones provide areas of seclusion for feeding, resting, breeding, rearing, hiding, and brooding. Vegetation overhanging the water provides hiding cover for salmonid fish.

+ Thermal Cover: Riparian vegetation provides thermal cover by ameliorating extremes in air temperature. Because of the location,

topography, presence of water, and the amount and diversity of vegetation, these areas are often cooler in the summer and warmer in the winter. Riparian vegetation helps maintain cooler water temperature necessary for high quality salmonid fish habitat. (Sachet, 1990)

Wetlands

In the wetland environment, water is the dominant factor that determines the nature of soil development, and the types of plant and animal communities living in and on the soil. Wetland habitats include marshes, swamps, bogs, seeps, wet meadows, and shallow ponds. Wetlands can also be defined as transitional lands between terrestrial and aquatic systems, where the water table is at or near the surface, or the land is covered by shallow water. Wetlands have one or more of the following characteristics:

+ The land supports predominately water-loving vegetation, at least periodically.

+ The substrate is predominately undrained saturated soil.

+ The substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season each year.

Wetlands have enormous value to wildlife and are often associated with riparian zones. All of the characteristics, attributes, and values to wildlife and fish discussed in the preceding Riparian section also apply to wetlands. Wetlands have a stabilizing effect on watersheds which in turn benefit wildlife habitat. Wetlands absorb and store flood waters and spring runoff, allowing a gradual, constant and less damaging flow into the aquatic system. Wetlands also serve as "living" filters that screen sediments, pollutants and debris from water before it enters streams, lakes or water table. Wetlands also serve as salmonid fish rearing habitat. (Sachet, 1990)

Meadows

There are two types of meadows: wet meadows, which can be considered wetlands, and dry meadows. Grasses, forbs, sedges, rushes, shrubs and scattered trees typify the vegetation of these meadows. The size varies from less than an acre to many acres depending on the physical characteristics of the site. One inherent characteristic is that the soil is either too shallow and rocky, or too wet to allow extensive establishment of conifers. The inherent edges formed around meadows, as with wetlands and riparian zones, are especially high in habitat richness. (Sachet, 1990)

Salmonid Fish Spawning and Rearing Areas

Resident and anadromous salmonids select spawning sites on gravel or cobble riffles. Resident salmonids generally select shallower, slower water, and smaller size gravel due to their smaller body size. Assuming the water depth, velocity, and cover requirements are met, successful spawning depends on an adequate supply of gravel or cobble and low sediment content. Incubating eggs require freely moving water in the spawning nest to supply high concentrations of dissolved oxygen and to remove metabolic wastes. Fine sediments clog the spaces between gravel and inhibit free movement of water. (Sachet, 1990)

Potential Impacts to Habitats

Any impact to key species caused by the type of boardwalk materials used is directly related to the impact on their habitat. Since none of the species actually feed on the boardwalk material the only way they could be affected is through contamination of their habitat. This would primarily be caused by harmful substances leaching out of the materials creating potentially toxic habitat. This could be very critical in the aquatic environment because any chemicals leaching out move more readily through water, and aquatic species are more sensitive to the effects of these chemicals. The salmonid fish spawning and rearing areas would likely be very vulnerable to these effects. Also, wetlands by their very nature of acting as "living" filters, are susceptible to the bio-accumulation of chemicals that may leach out of boardwalk materials. Over time this accumulation of chemicals could lead to the degradation of habitat.

Boardwalk Materials

Preservative treated wood and untreated wood have been used almost exclusively in the construction of boardwalks on the Mt. Hood National Forest, but plastic lumber is being investigated for use in some upcoming projects. Therefore, the materials this report will focus on are untreated wood, preservative treated wood and plastic lumber.

The type of material used in boardwalk construction is a concern because of the following: (1) the potential effects on habitats and key species; (2) maintenance and replacement costs increase with a decrease in structure life. Customer service is not a concern because all three material types meet the basic needs of the customer in terms of accessibility and the customer's recreation experience needs will be met if the framework of the Recreation Opportunity Spectrum (ROS) is followed.

The following discussion of each material type is organized into 4 parts: (1) a description of the material; (2) the average life of the material is identified (based on outdoor, ground contact use); (3) the average cost for the material, as it is used in boardwalk construction, is identified; (4) potential effects on the environment are described.

Untreated Wood

Western red cedar is the untreated wood most commonly used in boardwalk construction on the Mt. Hood National Forest, with hemlock and fir being used occasionally. These woods are all equally workable and adequate structurally for use in boardwalk construction, and they are similar in the effects their use has on key species and sensitive habitats. Cedar is the most decay resistant and economical in the long run of the three, and provides better customer service because of the need for less frequent replacement. Therefore, for the purpose of this report the only non-treated wood that will be considered is cedar.

The major chemical components of cedar are cellulose, hemicellulose, and lignin. These substances are of an innocuous nature with little chance of deleterious health effects. Cedar also contains accessory substances, generally termed extractives, which may produce toxic effects. The poisonous nature of some of these extractives provides a protective function to ward off the attack of bacteria, fungi, and insects. The heartwood of cedar contains such a high concentration of poisonous extractives that the lumber produced resists biological deterioration (Jagels, 1985). These poisonous extractives give cedar a natural resistance to decay and an average life of 15 years.

Costs for cedar have tripled in the last year and currently range from $1830 to $3970 / thousand board feet (MBF) depending on the size and grade. Based on the type of materials that would be needed for a typical boardwalk an average cost would be $2,200/ MBF (Baker, 1993).

There is very little literature on what effects the use of cedar has on the environment, and the literature searched focuses on the health risks to people, with the greatest concern being respiratory ailments caused by the wood dust during cutting and sanding (Jagels, 1985). Cedar is naturally occurring in the Forest; can generally be found in the areas on the Forest where boardwalks are needed; and the extractives which promote decay resistance in cedar are naturally occurring, have a low toxicity, and do not have a readily leachable nature. Based on this it can be assumed that the use of cedar in the construction of boardwalks has no deleterious effects on habitats or sensitive species.

Preservative Treated Wood

The sole purpose in treating wood with wood preservatives is to protect the wood from those organisms or circumstances which would destroy it (Webb, 1988). Wood destroying fungi and insects use wood for food or as a place to build their shelters. The most common method for controlling this deterioration is to remove the food source by introducing toxic preservative chemicals into the wood. This will greatly increase the service life of the wood by a factor of 5 times or more (Ritter, 1990).

Metallic materials have been used as wood preservatives for over a hundred years with the first successful preserving process developed in 1832 and the vacuum pressure impregnation method discovered in 1836. It is important to note that the development of the wood preservative industry in the United States really began to grow in the late 1800's as the supplies of naturally durable timbers decreased and treated wood was used as a replacement (Webb, 1988). This decline is still in evidence today as indicated by the increased cost and reduced availability of naturally durable woods, such as cedar, here in the Northwest.

Wood preservatives are broadly classified as either waterborne or oil-type, based on the chemical composition of the preservative and the carrier used in the treating process. Waterborne use water as the carrier during the treating process and oil-type use an oil or solvent as the carrier. The use of wood treated with oil-type preservatives, such as creosote and pentachlorophenol solutions, has largely been discontinued for use in the construction of boardwalks on the Forest, primarily for aesthetic reasons. They are visually oily, oily to the touch and have a strong odor. The exception is Copper Naphthenate because unlike the other oil-type preservatives it is less oily, has a moderate nonpersistent odor, is more visually acceptable and it is not currently on the EPA list of restricted use pesticides. This report will focus on the four most common types of wood preservative treatments used in boardwalk construction. Three of these are waterborne, Chromated Copper Arsenate-Type C (CCA-C), Ammoniacal Copper Zinc Arsenate (ACZA) and Ammoniacal Copper Quat-type B (ACQ-B); and one is oil-type, Copper Naphthenate. (see chart on page 35 for comparisons)

The basic premise of all four of these treatments is the same. They all consist of active ingredients that protect the wood from deterioration by insects and fungi, and agents that "fix" these active ingredients to the wood so they will not leach out. The differences are in the mix of active ingredients, the carrier, and the agents and chemical reactions that promote fixation.

The type of woods used for treatment with these preservatives are softwoods

such as hem/fir and Douglas Fir. When this report addresses preservative treated wood it is assumed that the wood type is that typically used in the industry for a particular preservative treatment. Based on this assumption the type of wood used for treating is inconsequential to this report.

Wood treated with CCA-C is olive green in color which weathers to a driftwood gray. The active ingredients in CCA-C are as follows:

Hexavalent Chromium, as CrO_8 ---------- 47.5%
Copper, as CuO ---------- 18.5%
Arsenic, as As_2O_5 ---------- 34.0% (AWPA, 1992)

Wood treated with ACZA is olive to blueish-green which weathers to a driftwood gray. The active ingredients in ACZA are as follows:

Copper, as CuO ---------- 50.0%
Zinc, as ZnO ---------- 25.0%
Arsenic, as As_2O_5 ---------- 25.0% (AWPA, 1992)

These ingredients are dissolved in a solution of ammonia (NH_3) in water.

The density and physical properties of both ACZA and CCA-C are essentially the same as untreated wood, and seasoning after treatment renders the wood dry, paintable, and odorless (Doyle, 1992).

CCA-C and ACZA are both waterborne arsenicals and are unique in that their chemicals react with the wood substrate. This reaction is termed "fixation" because the preservative compounds in the solutions are fixed in the woods in an insoluble state (Webb, 1988). This accounts for the permanency of the preservative in the wood (Webb, 1988). The chromium is the fixative agent in the CCA-C and the ammonia is the fixative agent in the ACZA. In CCA-C the chromium reacts chemically with the copper and arsenic fixing them in the

wood. After treatment of ACZA the ammonia evaporates causing the preservative to precipitate in solid form within the wood structure (JBaxter, 1991). The copper and zinc protect the wood against fungi, and arsenic protects against insects. The arsenate forms of these preservatives are very insoluble components in virtually all soils and move only by erosion.

CCA-C is probably the most widely used preservative in the world (Greaves). This treatment is very affective when used with softwoods, but does not have a good retention when used with denser, less porous woods such as Douglas Fir. This prompted the development of ACZA which is recommended for the treatment of Douglas Fir in place of CCA-C. ACZA is the only waterborne pressure treatment available to penetrate Douglas fir and assure compliance with AWPA standards (JBaxter, 1991).

The life of wood treated with CCA-C and ACZA is difficult to determine because these specific treatments have only been around for 55 years. An average life of 40 years can be assumed based on controlled studies and manufacturers' guarantees. Various tests on treated southern pine piling indicated all poles were sound and in excellent condition after 32 years and would probably last at least 100 years (Arsenault, 1975). Life after 40 years would depend on wood species, use and efficacy.

Costs for preservative treated wood have remained fairly stable for the last few years with costs of 4x4 and larger averaging $650/MBF for the lumber (hem/fir) and $110/MBF for treating (CCA-C) for a total cost of $760/MBF (Baker, 1993). This is less than half the cost of cedar.

Wood treated with copper naphthenate may range from light green to dark brown in color depending on the treating process, the solvent, and the treating temperature. Copper naphthenate is a solvent soluble wood preservative. The solvent used depends on the commodity which is being treated. The most commonly used carrier solvents are fuel oil and mineral spirits. Wood treated with copper naphthenate in oil has a characteristic petroleum aromatic odor. Wood treated with copper naphthenate in mineral spirits has a characteristically

aliphatic hydrocarbon odor (Doyle, 1992). The heavier oil preparations are used to treat timbers used in ground contact applications.

The advantages of copper naphthenate over the waterborne arsenicals are the absence of arsenic and the use of oil or solvent as the carrier instead of water. The absence of arsenic makes it less hazardous to people during the treatment process and a treatment that does not contain arsenic is more readily accepted by people. The use of oil or solvent as the carrier makes the treated material less susceptible to cracks and checking which is important in materials like glu-lam stringers for bridges where cracks could alter the structural integrity. For different reasons, the absence of arsenic and the use of oil or solvent as the carrier are a disadvantage. The lack of arsenic makes the wood more susceptible to insect attack, and the odor and look of the oil or solvent is less acceptable in trail applications than the neutral odor and look of the waterborne preservatives. Copper naphthenate is primarily a fungicide with little to no termiticidal properties (Greaves, 1987).

The life of wood treated with copper naphthenate can be expected to last as long as the waterborne arsenicals if the proper oil preparation is used for the intended application. The United States Department of Agriculture Forest Products Laboratory reports test stakes in the ground for over 27 years having no significant failure from decay or insect attack (Permapost, 1991). The cost for wood treated with copper naphthenate is slightly higher than the cost for CCA-C treated wood.

Ammoniacal Copper Quat preservative treated wood will vary in color from brown to a deep olive green depending upon wood species, chemical retention, and heartwood. All species of wood will weather to a brown tone over time as the wood is exposed to sunlight. The active ingredients in ACQ-B are as follows:

Copper as CuO ---------- 66.7%

Quat as didecyldimethylammonium chloride ------ 33.3%

(AWPA, 1992)

These ingredients are dissolved in a solution of ammonia (NH_3) in water.

ACQ is more affective in preserving some hard-to-penetrate wood species like Douglas Fir than the non-ammoniacal water-borne preservatives, and for most species there is no need for incising to achieve appropriate preservation penetration (JBaxter, 1992). The advantages of ACQ over the waterborne arsenicals is similar to that of the copper naphthenate due to the absence of arsenic and chromium. It is also more acceptable for use than the copper naphthenate because it is waterborne and does not contain oils or solvents.

Over the past decade, the effectiveness of ACQ preservative treated wood has been thoroughly demonstrated through a variety of industry-approved accelerated testing methods performed by several independent laboratories. Such tests include soil block, soil bed exposure, and field stake tests. Compared at all levels of preservative retentions in field stake tests, ACQ preservative treated wood exhibits performance equivalent to ACZA and CCA (JBaxter, 1992). It can be assumed based on these test results that ACQ preservative treated wood will have an average life similar to CCA and ACZA treated wood, which is 40 years. This is only an estimate since ACQ has only been around as a preservative for the last 5 years.

The cost for the wood treated with ACQ preservative is similar to the cost for CCA-C preservative treated wood.

There is very little literature related to how the use of preservative treated wood affects the environment. The bulk of the literature that does exist focuses on the leachability of the preservative chemicals from the wood with assumptions made on their potential effect on the environment. A few studies have been conducted on the toxicity of the preservatives and on the biological impact of preservative treated wood to organisms, but no literature was found relating to field studies of the biological impact to organisms caused by the use of pressure treated wood.

The USAEHA (1988) toxicity study involved the determination of the appropriate lethal dose of copper naphthenate on mammalian, avian, and aquatic test systems to assess acute toxicity. The conclusions this study reached were:

1. Copper naphthenate does not appear to cause dominant lethal effects in a mammalian test system.

2. Dosage with copper naphthenate in two species of bird failed to produce significant observable toxic effects at high dietary concentrations. This finding would indicate that the compound would have little or no impact on wildfowl in the event of environmental contamination.

3. Aquatic toxicity appears to be of greater concern in that copper naphthenate is categorized as moderately toxic to bluegill and highly toxic to trout.

It is important to note that this study focused on the toxicity of the preservative and the negative results may be inconsequential with relation to the effects of preservative treated wood on the environment. The merit of this study is the determination of how selected systems would be affected by a given quantity of copper naphthenate.

The Weiss (1988) study is a little more closely related to the effects of treated wood on the environment. This study was conducted on the biological impact of CCA treated wood on selected Estuarine organisms. In this study, tests were conducted on mollusks, algae, crustaceans and fish in a confined environment (aquarium) using various sizes of preservative treated wood. The results indicated that mortality and a retarded limb regeneration rate occurred in fiddler crabs; mortality was noted to embryos of the mummichog; chlorophyll content of algae was reduced within a few days; and snails became moribund and died within a few days (Weis, 1988). The general conclusions drawn from these tests indicate that metals do leach out of CCA treated wood and that these metals can

be toxic to estuarine species from several taxa. These effects decreased dramatically with a decrease in wood size and with replacement of the water in the tank. Also, the leaching rate diminishes over time which means the toxicity would continue to be reduced with further elution (Weis, 1988). The experiments conducted here do not mimic the natural environment and the confined environment of these experiments allowed the chemicals to build up to acutely toxic levels (Weis, 1988).

In the Breteler (1992) critique of the Weis study it was suggested that from a risk assessment point of view the results are meaningless. In the risk assessment process the margin of error of the experiment is understood and extrapolation to the real world can readily be made. This was not apparent in the Weis study for the following reasons:

+ A segment of CCA pressure treated wood was used in a small aquarium under intermittent static conditions (water is only replaced weekly) allowing maximum build up of the metal concentrations. This affected both the magnitude and duration of exposure compared to the natural environment.

+ An unrealistic wood surface to water volume was applied which even under backwater conditions is not realistic.

+ Artificial water with a low suspended particulate load was used. This eliminated the natural chelation process which serves as a metal detoxification mechanism in coastal waters.

"From a risk assessment point of view, the experiment results appear to demonstrate "absence of risk" of CCA-treated wood to marine life." (Breteler, 1992)

More directly related to the use of preservative treated wood and it's effect on the environment is the Kalnins et al (1984) study involving the effect of CCA and copper naphthenate wood preservative treatment of beehives on honey bees and

hive products. The conclusions of this study were:

+ CCA preservative treatment of hives may weaken colonies, kill significant numbers of bees that come in contact with the newly treated wood, and contribute to winter kill. CCA treatment of hives resulted in elevated arsenic and chromium levels in bees. It was suggested that CCA not be used for treatment of beehives except for hive parts that rarely come in contact with the bees.

+ Treatment of beehives with copper naphthenate resulted in few adverse findings with winter survival comparable to that in controls. Protection of wooden beehive parts without detrimental effects on bees, honey, and wax should result from treatment with copper naphthenate.

This would indicate that preservative treated wood containing arsenic could have a detrimental effect on insects if this material is used in the construction of their habitat.

As mentioned earlier, the bulk of the studies researched focused on the leachability of the preservative chemicals from the wood. The following is a sampling of those studies.

The DeGroot (1979) studies were conducted on the changes in arsenic, copper, and chromium content of soils surrounding pine stakes treated with CCA in the 1940's and exposed for 30 years in the ground. The results showed that the concentrations of arsenic, chromium, and copper were not significantly different from background levels in soils >12 inches below the stakes and >6 inches laterally from the stakes. Analysis of sections taken from randomly selected stakes indicated that the wood preservatives are strongly fixed within the wood. The conclusions were that wood treated with CCA and used in acidic soils will not contribute significant amounts of Arsenic or chromium into the surrounding soils and waters. The distribution of copper is similar to arsenic and chromium, but not as precise.

In the Arsenault (1975) study of permanence, effectiveness, durability, and environmental considerations of CCA-treated wood foundations it was summarized that there was no significant leaching of the preservative components and no environmental hazard to ground water, soils, plants, or animals. This study included data from 32 year old southern pine pole lines, 28 year old experimental pine posts, and 18 year old piling.

In a simulated acid rain study on CuNap treated poles and the subsequent monitoring of a field installation with three of these poles indicated a loss of copper at such levels that the use of CuNap treated wood in water or where runoff occurs directly into surface water could result in environmental contamination. This copper loss is not a concern in soils because the volume of contaminated soil around a piece of treated wood is relatively small and terrestrial ecosystems are not significantly affected. (Doyle, 1992)

It is undisputed that the ingredients used in preservative treatments are hazardous at high enough concentrations. Copper, chromium, and zinc are classified as heavy metals. These metals are some of the minor or trace elements essential to plants and animals, but are toxic to organisms if present at high enough concentrations (Ireland, 1991). What is not as clear is the effect the use of wood treated with these preservative chemicals has on the environment. The ingredient of most concern appears to be copper and only then in relation to aquatic systems. Copper toxicity is of little concern to mammals and birds, but aquatic systems are sensitive to copper (Doyle, 1992). The biggest factor though is not the chemicals themselves, but to what degree they are fixed in the wood. This is directly related to the quantity of chemicals leached into the environment. Leaching losses depend on many factors including fixation variables such as temperature, relative humidity, formulation, age in service, and rainfall conditions; and incomplete fixation is a factor to be considered in predicting short-term environmental contamination (Doyle, 1992).

Plastic Lumber

Turning plastic waste into engineered products is a new technology that utilizes

mixed plastic scrap from post-consumer collections. An obvious market for this endeavor is the outdoor lumber market, but several criteria needed to be satisfied, such as:

(1) The lumber needed to be compatible, of adequate physical strength, and produced at low cost.

(2) The lumber needs to be designed to allow the use of standard wood working tools, nails and other fasteners.

(3) An economical process for continuous extrusion allowing a high rate production of large cross-section and long pieces (areas where natural wood becomes disproportionately expensive) had to be used.

This criteria was met with the creation of Trimax which is an extruded, plastic wood substitute based on mixed plastic scrap. This lumber is glass-reinforced with a structural foam core produced in a large throughput extrusion process. Lumber-like shapes can be produced in widths up to 12" and lengths to 36'. The density of this plastic lumber can be adjusted to match that of it's main competition, natural wood (ie. Southern Yellow Pine #2, 2.5 CCA treated). Also this plastic lumber can be produced at costs that are competitive with natural woods. (Mack, 1990) The cost for plastic lumber based on an estimate obtained for the Trillium Lake trail project in March 1993 averages out to $2400/MBF (Baker, 1993).

In tests conducted on plastic lumber composed of glass-reinforced, structural foam it was determined that there is a sufficiently high physical strength to allow competitive substitution of natural wood. Other tests have shown that Trimax plastic lumber is insect resistant, chemical resistant, and in outdoor exposure will not rot or splinter. It's color may fade under prolonged exposure to the sun, but it is highly resistant to swelling and cracking due to multiple freeze/thaw cycles (Trimax). Therefore, it can be assumed that plastic lumber of this type will have a life equal to that of preservative treated wood and probably longer. At least where decay due to insect and fungi is concerned. These are only assumptions

since plastic lumber has only been around for a few years and has not undergone studies of it's durability and life, over time. There are some concerns with the use of plastic wood regarding how it reacts to temperature extremes and various loading (ie snow loads and heavy foot traffic) with respect to deformity and sagging.

Leaching tests under U.S. Environmental Protection Agency guidelines have shown Trimax plastic lumber to be within the maximum allowable concentrations limits. This material is not regulated under the Resource Conservative and Recovery Act (RCRA) hazardous waste regulations (Trimax). This information, and claims that the use of plastic lumber eliminates hazardous chemicals leaching into our environment (Environtek, 1992) is the only data related to the effects the use of plastic lumber has on the environment. In the literature searched there were no studies conducted on the use of plastic lumber in the environment therefore no assumptions can be made.

PRESERVATIVE TREATMENT MATRIX

PRESERVATIVE TREATMENTS	AVERAGE LIFE	ACTIVE INGRED-IENTS	TYPES OF MATERIAL TREATED	COSTS ($/MBF)	CARRIER USED IN THE TREATING PROCESS
Cromated Copper Arsenate Type C (CCA-C)	40	Copper, Arsenic	Softwoods	$110	Water
Ammoniacal Copper Arsenate (ACZA)	40	Copper, Arsenic, Zinc	Softwoods, Douglas Fir	$110	Water
Ammoniacal Copper Quat-Type B (ACQ-B)	40 1/	Copper, Didecyld-imethyla-mmonium Chloride	Softwoods, Douglas Fir	$110-130	Water
Copper Naphthenate	40 2/	Copper	Softwoods, Douglas Fir, Glu-Lam	$110-130	Oil

1/ Estimate is based on accelerated testing methods.

2/ If the proper oil preparation is used for the intended application.

Boardwalk Material Guidelines

The development of guidelines for the use of boardwalk materials is made difficult by the lack of definitive answers on what effects the various material types have on the environment. Specifically key species and sensitive habitats. The approach that will be taken in this section will be to develop subjective guidelines based on the literature researched, personal contacts, assumptions made, and the biological evaluation process (FSM 2677.43). The biological evaluation process is intended to conduct and document activities necessary to ensure proposed management activities will not likely jeopardize the continued existence or cause adverse modification of habitat for:

A. Species listed or proposed to be listed as endangered (E) or threatened (T) by the USDI-Fish and Wildlife Service.
B. Species listed as sensitive (S) by USDA Forest Service Region 6.

This approach is for the short term until more conclusive tests can be conducted that either supports or refutes the literature and assumptions made.

Short Term Guidelines

There are a number of factors that need to be considered when developing guidelines for the type of materials to use in the construction of a boardwalk trail. The two primary factors include the cost and durability (life) of the materials, and the effects the materials may have on the environment. The difficulty comes in determining what the acceptable level of risk is and if the benefit is worth the expense. For example, in a 1991 Office of Management and Budget cost benefit analysis it was estimated that the costs of enforcing the regulation listing preserving chemicals as a hazardous waste would equate to $5,700,000,000,000 per premature death averted (Oregonian, 1993). The benefit in this case does not support the expense. A similar rationale needs to be applied in determining the acceptable level of risk in the selection of boardwalk materials.

Cost and Durability

In the past, cost and durability have typically been the primary factors in selecting boardwalk materials and the selection has been relatively simple. When compared to the costs of cedar and plastic lumber, preservative treated wood is the most economical material to use in the construction of boardwalks.

The cost for cedar has risen dramatically in the last few years in tandem with the reduction of old growth logging, and cedar will last on average only half as long as preservative treated wood. Taking this into account the use of cedar will cost from 3 to 4 times more than the cost for preservative treated wood. Also, as the quality of the cedar drops from old growth to second growth the durability also drops. This will widen the cost gap between cedar and preservative treated wood.

Plastic lumber is estimated to have a life at least equal to that of preservative treated wood, but the cost for the material and construction is estimated to be 50% higher. There are many unknowns with plastic lumber including how it will withstand temperature extremes and ozone, if it will begin to sag under heavy use, and plastic's tendency to "creep" over time. The use of plastic lumber is unacceptable in primitive, semi-primitive non-motorized, semi-primitive motorized, and roaded natural settings, and inconsistent with rural settings. This is based on the guidelines established in the Recreation Opportunity Spectrum (ROS, 1990). The largest majority of the trails on the Mt. Hood NF fall within these five settings which would limit the opportunities to use plastic lumber.

Environmental Effects

In the past few years the issue involving the effects of boardwalk materials on the environment has emerged as another primary factor in the selection of boardwalk materials. As explained earlier the decisions involving this factor are not as "cut and dry" as those involving cost and durability. The main issue here that needs to be addressed in the development of guidelines is to determine if the amount of in-service losses of chemical components is acceptable with respect to sensitive habitats. These in-service losses of chemical components are

a direct result of leaching.

In my research no studies could be found on the leaching of poisonous extractives from cedar. These extractives are naturally fixed in the wood and it can be assumed that any leaching that may occur would come from the wood surface (wood oils) and would be minimal. Cedar and other natural woods are assumed to be innocuous to the environment probably due to the fact that they are naturally occurring and have been unaltered with the addition of chemicals. Therefore it is assumed that the in-service losses from cedar would be at a level that is acceptable with respect to sensitive habitats.

Plastic lumber is composed of recycled plastics in which some of the chemical components are toxic including some heavy metals, but these components are in encapsulated form. Laboratory tests have shown that the leaching of these chemicals is within the maximum allowable concentration limits (Trimax). Most of the recycled plastics have a history of being used for the containment of foodstuff (recycled milk bottles, soda bottles, etc.). Therefore it can be assumed that in-service losses from plastic lumber would be at a level that is acceptable with respect to sensitive habitats, but research is needed to substantiate this assumption.

All preservative treated wood will leach some of it's chemical components (metals). The in-service losses of metals with respect to the rate of loss is similar for wood treated with CCA-C, ACZA, or ACQ (copper naphthenate will be addressed separately). The differences are in the type of metals they contain that may leach out. The metal that is of greatest concern is copper which is a key component of all three of the preservatives. The chromium (CCA-C) is also a concern, but not to the extent of copper. The arsenic (CCA-C, ACZA) is not a concern with respect to the environment (Doyle, 1992), but has negative connotations to people (Culp, 1993) which clouds it's use. Incomplete fixation and surface residue are the key factors to be considered in predicting short-term environmental contamination. The leaching can be minimized if the wood is treated properly and enough time is allowed for maximum fixation of the metals to occur. With proper fixation the only leaching that occurs is from surface

residue because wood is impervious to water and there is no other exit for the metals. Complete fixation occurs eventually and the surface residue can be removed before the wood is put into service.

The loss of copper from copper naphthenate treated wood is up to three times greater than from the waterborne preservatives CCA-C, ACZA, and ACQ. Also, as an oil-based preservative the mitigation measures of testing for fixation, and washing and scrubbing will not apply.

General Guidelines for Sensitive Habitats

These guidelines focus on sensitive habitats, but they are directly related to key species because key species are affected by contamination of their habitat. The following guidelines can generally be applied to all four of the sensitive habitat types including riparian zones, meadows, wetlands, and salmonid fish spawning and rearing areas.

(1) Avoid locating trails in these habitats whenever possible. When unavoidable, minimize the need for boardwalks through careful trail loction.
(2) Locate trails as far from surface water as possible to avoid contamination. This provides a buffer zone for contaminants since they move less freely in soil as opposed to water. Also, the aquatic species are more sensitive to contamination.
(3) Cross these habitats at their narrowest points to reduce the amount of boardwalk needed and the habitat contact time.
(4) Minimize the number of stream crossings for the same reasons as (2) and (3) above.
(5) Determine the occurrence of key species and refer to their specific planning guidelines.

IV. RECOMMENDATIONS

When comparing the cost benefits and the risks with respect to the biological evaluation process, preservative treated wood is the recommended material to use in the construction of boardwalks. The biggest risk in it's use is the leaching of copper, and this can be reasonably mitigated. Therefore, if certain mitigation measures are met it is assumed that the in-service losses from these preservative treated woods would be at a level that is acceptable with respect to sensitive habitats.

These mitigation measures are:

+ Insure complete fixation in CCA-C preservative treated wood by having the following test performed: AWPA Standard A3, section 11, Method for Determination of the Presence of Hexavalent Chromium in Treated Wood. The presence of hexavalent chromium gives a good indication if complete fixation has occurred.

+ Insure complete fixation in ACQ and ACZA preservative treated wood by requiring that the wood have a chance to "cure" for at least 60 days which will help insure complete fixation. After the 60 day period if the wood has a slight or no odor of ammonia then fixation is complete. There is a test for fixation that although it is in the trial stages it would still be beneficial to perform as another method to check complete fixation. The procedure is to take a boring from a random sample and place it in water. If any color is present then the ammonia is still evaporating. If there is no color and the water remains clear then the ammonia is not present. Complete fixation occurs in these ammoniacal preservatives when the ammonia has evaporated off. This is typically within 24 hours, but depending on temperature, humidity, and how the wood is stacked (relates to air flow) it could take over a month for complete fixation.

+ These preservative treated woods should be washed and scrubbed, with water and a stiff brush, if they are used directly in (or if a significant amount of runoff from the treated wood is likely to enter) a surface water system which is a key habitat for a sensitive species. This is most critical if the surface water system is a salmonid fish hatching and rearing habitat.

+ When boardwalks are constructed in an area where there is a strong likelihood that a sensitive species (such as an amphibian) will utilize the area around and under the wood as habitat then the material should be washed and scrubbed as above. If the boardwalk is also in an acid bog then it may be desirable to replace the ground contact portions (typically the sills) with plastic lumber.

The type of preservative treatment recommended for most applications of boardwalk construction is ACQ. The reasons for this are as follows:

+ It does not contain arsenic or chromium which enhances worker safety as well as reduces the chances of leaching these heavy metals into the environment. This absence of arsenic is also more acceptable to people.

+ It's preservative retention (which relates to decay resistance) is equivalent to CCA-C and ACZA.

+ It is effective in treating hard to penetrate woods like Douglas fir.

+ It is EPA-registered as a "General Use" pesticide and is not subject to the most stringent provisions of the Federal Insecticide, Fungicide and Rodentcide Act or the Resource conservation and Recovery Act. This means that the wood scraps are not classified by EPA as hazardous.

+ In most species of wood there is no need for incising to achieve appropriate protection of the preservative. The absence of incising marks gives the wood a more natural appearance.

+ It can be used in most ROS settings which is less restrictive than plastic lumber.

+ It has a longer service life than cedar. This has the obvious advantage of being more cost effective, but it is also less invasive to the environment because it does not have to be replaced as often.

+ ACG preservative wood was used to construct a roof over a commercial drinking water reservoir in California. This indicates a high comfort level for this preservtive from a State that has some of the most stringent laws regulating environmental concerns in the country.

The advantage of copper naphthenate is that it is oil based and therefore more suitable for treating glu-lam members than the waterborne preservatives. Glu-lam beams are often used in the construction of trail bridges. "Bleeder" material should be rejected and not used because it is more likely to cause contamination of the environment. Other than for the bridge applications already mentioned, copper naphthenate is not recommended for use in boardwalk construction where run-of (oil or water) can enter sensitive aquatic habitats because of the high in-service losses of copper.

IV. MONITORING

The development of a monitoring plan is necessary to address the validity of the assumptions made during identification of boardwalk materials, key species, sensitive habitats, and boardwalk material guidelines. This monitoring plan can be considered assumptive monitoring. This is the process of identifying the assumptions to test, selecting sample sites, collecting physical information that reflects the assumption and interpreting the data.

The following assumptions were made during the identification of boardwalk materials, key species and sensitive habitats, and were based on existing literature.

(1) The type of boardwalk material may cause an unacceptable reduction in key species due to the in-service losses of chemical components.
(2) The type of boardwalk material may cause an unacceptable reduction in sensitive habitat quality due to the in-service losses of chemical components.
(3) Boardwalk material guidelines will maintain changes in key species numbers and habitat quality at acceptable levels by controling the in-service losses of chemical components.

Monitoring Plan

The objective of the following monitoring plan is to test the validity of the assumptions that were identified above. This monitoring plan is split into two parts.

The first part is a species and habitat matrix which outlines the monitoring method, unit of measure, monitoring frequency, and threshold of variability for each key species and sensitive habitat. A large portion of this matrix was developed in the Sachet (1990) report. The only avian species that will be included in this plan is the greater sandhill crane because it is the only one likely to be affected by the type of materials used, and even this is remote.

The second part addresses the need to monitor the in-service losses of chemical components from the boardwalk materials and how they affect key species. Monitoring these in-service losses requires setting up a special test project. A proposal outlining this test project was developed and submitted to the USDA Forest Service, Technology and Development Program. A copy of this proposal follows the species and habitat matrix.

SPECIES AND HABITAT MATRIX

A. SPECIES REDUCTION

Objective: Determine whether key species numbers are declining.

B. SENSITIVE HABITAT QUALITY

Objective: Determine whether the quality and usability of sensitive habitats has decreased due to the type of boardwalk materials used.

KEY SPECIES OR SENSITIVE HABITAT	MONITORING METHODS	UNIT OF MEASURE	MONITORING FREQUENCY	THRESHOLD OF VARIABILITY
Greater Sandhill Crane	Breeding Success: activity and	Number of fledglings	Biennial	Decrease in Population
Cope's Giant Salamandar/ Red-legged Frog	Population composition, density & distribution	Individual	Biennial	Decrease in Population
Painted Turtle/ Western Pond Turtle	Population composition, density & distribution	Individual	Biennial	Decrease in Population
Salmonid Fish & Spawning Areas	**	**	Annual	**
Aquatic Invertebrates	Population composition, density & distribution based on representative sample obtained through hand-picking or kicknet	Individual	Annual	Decrease in Population
Riparian, Wetlands & Meadows	Breeding success/ species counts	Number of fledglings/ annual key species	Biennial/annual	Decrease in population/ + or - 10% variation from normal population fluctuation

** Refer to Forest Monitoring Plan.

PROJECT PROPOSALS
USDA Forest Service, Technology and Development Program

Project Name/Title: Effects of Boardwalk Materials on Sensitive Habitats and Key Species.

Submitted by: Mike Tippie

Unit: Mt. Hood National Forest, Supervisor's Office

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Date: 3/20/93

OVERALL OBJECTIVES/PROBLEM STATEMENT
(Describe the problem, how the work is currently being done, and why improvement is needed).

There is a lack of established standards or guidelines for the acceptable use of boardwalk materials in sensitive habitats. Currently the acceptability varies depending on which District the project is on and which specialist you are working with. This has caused project delays, shortened life spans for structures, possible unacceptable use of some types of materials in sensitive habitats, and difficulties for the line officer in making decisions regarding the acceptability of projects. The problem in developing guidelines is there have been no field tests conducted to determine the leaching rate of boardwalk materials and what effect they may have on the sensitive habitats and key species.

PROPOSED TECHNOLOGY AND DEVELOPMENT WORK
(Describe your concept of the end product, ie. a new equipment design, a video production, a handbook, etc.)

The desired end product would be test results showing the leaching rates of various boardwalk materials and the toxic effects on selected sensitive species.

Phase 1 -

Conduct actual field tests using the following boardwalk materials:

Chromated Copper Arsenate (CCA-C) Preservative Treated Wood
Ammoniacal Copper Quat (ACQ) Preservative Treated Wood
Ammoniacal Copper Zinc Arsenate (ACZA) Preservative Treated Wood
Copper Naphthenate Preservative Treated Wood

Plastic Lumber
Cedar

Two test samples of each type of preservative treated wood should probably be used. One sample as it comes from the supplier and one sample after it has been washed to remove surface residue and stored for a period of time to enhance more complete fixation.

These tests would need to determine the type and amount of the chemical components (if any) that leach out of these materials under the following conditions:

1. Direct contact with standing water. (lakes, streams, etc.)
2. Direct contact with ground that is generally wet. (boggy, marshy areas)
3. Direct contact with ground that is generally dry. (areas that may be saturated during spring runoff, but dry up quickly)
4. No direct contact with 1 -3 above. (such as a bridge over water, or elevated boardwalk sections over wet or dry ground)

The tests would need to determine the amount of contaminants in the soil and water over various time intervals. There should also be control plots to determine existing levels of these chemical compounds.

Phase 2 -

Conduct simulated and/or field tests to determine the toxicity levels of sample boardwalk materials or the chemicals used to preserve them (if applicable) on the following species groups:

1. Aquatic - Salmonid fish
2. Amphibian - Cope's giant salamander, red-legged frog
3. Aquatic Invertebrates - Caddisfly species

By utilizing the results of these tests an objective determination can be made on the type of materials that are acceptable for use in boardwalk construction with respect to sensitive habitats and key species.

The Mt. Hood NF would be willing to assist in this project by providing the test sections, including the boardwalk materials, and in the gathering of samples.

POTENTIAL BENEFITS
(describe how this project will improve safety, reduce cost, save time, increase efficiency, or provide improved resource management).

This project will reduce cost and improve efficiency by reducing the amount of work required to develop biological evaluations for trail projects involving boardwalks. Specialists will not have to continuously "reinvent the wheel" for each project and the results will be more objective.

Costs can be greatly reduced by using the most durable, decay resistant material possible, but without the results from this project specialists will undoubtedly select the least risk option which is natural wood. Preservative treated wood and plastic lumber last 2 to 5 times longer than natural wood and with boardwalk costs averaging $32/LF this could be a substantial saving.

There would also be benefits if this project determines that any of these material types are not acceptable for use in a given habitat. Resource management would be improved by eliminating the use of unacceptable materials. Another benefit would be to encourage industry to make improvements in their products so they are acceptable.

The results of this project would also be far reaching, going beyond the Mt. Hood NF and the Forest Service. Other agencies such as the National Park Service and Bureau of Land Management, as well as state and local recreation and park departments, would benefit from this information in the development of their trails.

Therefore, this project will reduce cost, save time, increase efficiency, and provide improved resource management which equates to better customer service.

V. FUTURE RESEARCH NEEDS

The primary research needs are as follows:

(1) Monitoring of a broader range of sites for the type and quantity of components that leach out of the various types of boardwalk materials under natural conditions.

(2) Soil and water around in-service boardwalk material should be monitored for long periods of time to determine accumulation effects of leached components.

(3) A broader range of aquatic species should be studied to determine toxicity levels of the components that may leach out of boardwalk materials.

A large part of the future research needs would be accomplished if the USDA Forest Service, Technology and Development Program selects the project proposal identified in this report.

VI. SUMMARY

The goal of this project was to integrate the selection of construction materials for boardwalks with the needs of sensitive habitats and key species. Another goal that surfaced while preparing this report was to instigate needed research that would provide better data on the environmental effects of boardwalk materials. These goals were accomplished by meeting the objectives originally identified and through the submittal of a project proposal calling for more definitive testing. This project made it clear that the selection of boardwalk material is very subjective with respect to it's affects on key species and sensitive species, and the risks need to be weighed against the benefits.

With the decline in our natural resources, such as wood, and increasing costs for construction materials it is important that we utilize the most durable cost effective materials possible. At the same time we must protect key species and sensitive habitats. This project is the first step in integrating the needs of sensitive habitats and key species with the selection of boardwalk materials.

The recommendations beginning on page 40 should be referred to in making decisions regarding the selection of boardwalk materials.

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